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CR-136886

THE USE OF ERTS IMAGERY IN RESERVOIR
MANAGEMENT AND OPERATION

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(E74-10485) THE USE OF ERTS IMAGERY IN
RESERVOIR MANAGEMENT AND OPERATION
Interim Report, Jul. - Dec. 1973 (Corps
of Engineers, Waltham, Mass.) — 30 p HC
\$4.00

N74-22009

Unclass
00485

28 CSCI 08H G3/13

January 1974

Type II Interim Report for Period July-December 1973

Prepared for
GODDARD SPACE FLIGHT CENTER
Greenbelt, Maryland 20771

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.	
4. Title and Subtitle The Use of ERTS Imagery in Reservoir Management and Operation		5. Report Date January 1974	
		6. Performing Organization Code	
7. Author(s) Saul Cooper		8. Performing Organization Report No.	
9. Performing Organization Name and Address Department of the Army New England Division, Corps of Engineers 424 Trapelo Road Waltham, Massachusetts 02154		10. Work Unit No.	
		11. Contract or Grant No. S-70256-AG	
12. Sponsoring Agency Name and Address Mr. E. Szajna ERTS Technical Officer Code 430, GSFC Greenbelt, Maryland 20771		13. Type of Report and Period Covered Type II Interim Report July-December 1973	
		14. Sponsoring Agency Code	
15. Supplementary Notes.			
16. Abstract Studies at the New England Division, Corps of Engineers are focused on evaluating the possible usefulness of ERTS DCS and imagery to its watershed management functions. Twenty-six DCP's have been installed in the field and are reporting hydrologic data on a near real time basis via a direct teletype link with Goddard Space Flight Center. DCS equipment is operating with a high degree of reliability and a minimum of maintenance and has again been used in an operational mode during a significant flood period. The results of a Corps-wide questionnaire regarding automated data collection are compiled and presented in this report. Using imagery-photo interpretation techniques, methods are being developed to delineate flooded areas, snow cover and icing in rivers, lakes and reservoirs. An imagery mosaic has been prepared highlighting surficial water features of the New England region. A man-interactive computer system with a CRT and light pen is being developed that could lead to a better use of real time ERTS computer compatible imagery for important water resource management decisions.			
17. Key Words (Selected by Author(s)) reservoir regulation, watershed management, hydrometeorological data collection		18. Distribution Statement	
19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages 28	22. Price* 4.00

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PREFACE

The New England Division (NED), Corps of Engineers is participating in the ERTS-1 experiment to assess the possible usefulness of satellites such as ERTS in the fulfillment of its watershed management functions. We are studying both DCS and imagery in this regard. Our DCS studies encompass two separate goals: one - to determine the viability of satellites for the relay of real time hydrometeorological data for watershed management purposes, and the other - to aid in the selection of the most economically feasible and technically useful layout of data collection points to provide all the necessary information for the optimal regulation of a river basin. Our imagery studies are focused on the evaluation of the ability of ERTS imagery to provide useful and timely supplementary hydrologic information. Our work has been centered on both photo interpretation and computer-oriented analyses of the imagery.

As of 31 December 1973, we have installed 26 of our 27 DCP's that report hydrologic information on a near real time basis via the direct teletype link with Goddard Space Flight Center. Analyses of the DCS data products indicate a very high degree of reliability with a minimum of maintenance. In fact the system has once again been used in an operational mode during the December floods in New England. Over the past six months we have received completed questionnaires from Corps of Engineers offices throughout the United States regarding the present status of and future needs for automated data collection facilities. The results have been compiled and are presented in this report.

It appears that flood storage characteristics of river flood plains and wetlands can be delineated by use of imagery - photo interpretation techniques. In addition, photo interpretation appears well suited in aiding the preparation of snow maps and also in following the progress of icing of rivers, lakes and reservoirs. A mosaic of the New England area at a scale of 1:500,000 that highlights the surficial water features of the region has been prepared in duplicate for NED by the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL).

A man-interactive computer system with a CRT and light pen is being developed that could lead to better use of real time ERTS computer compatible imagery for important water resource management decisions.

2.0 DCS STUDIES

2.1 BACKGROUND

The DCS studies are described in detail in our data analysis plan and involve two separate goals: (1) to determine the viability of satellites such as ERTS for the relay of real time hydrometeorological data for watershed management purposes, and (2) to aid in the selection of the most economically feasible and technically useful layout of data collection points to provide all necessary information for the optimal regulation of a river basin.

2.2 SUMMARY OF PROGRESS

2.2.1 Introduction

Location of operating DCP's and a proposed site for future installation are included in table 1 on page 3.

CRREL is using two DCP's to intermittently test temperature, water quality and other environmental sensors. An additional platform, assigned to the U.S. Geological Survey, is included in our teletype reports from the Goddard Space Flight Center (GSFC).

We are continuing to receive DCS data via a near real time link with GSFC. This data is being acquired on punched paper tape and teletype printout. DCS data on punchcards and computer printouts are also being supplied by GSFC via mail.

2.2.2 DCP Installation, Maintenance and Performance

At the end of the reporting period - 31 December 1973, 26 platforms had been installed, with 23 in the field, 2 at CRREL, and 1 at NED headquarters. Eight installed platforms have malfunctioned, four more than once. There has been a total of 13 DCP failures, eight occurring in two months or less after installation and 10 in five months or less (see table 2). The DCP's that have never failed have experienced long lifetimes, averaging 11 months.

The 24-volt Gel-Cell battery sets (each consisting of

1.0 INTRODUCTION

The purpose of this report is to summarize the results of our ERTS-1 experiment during the past six months and to report in detail the progress of our study since the last report, dated 15 December 1973. The imagery analysis and imagery/DCS interaction portions of our investigation are subcontracted to the University of Connecticut (UCONN) at Storrs, under the direction of Dr. Paul Bock. This contract with amendments extends from 1 July 1972 through 30 June 1974. In certain aspects of the DCS and imagery segments of our studies we are also cooperating with the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL), Hanover, New Hampshire. During the past six months personnel from these organizations attended several working group meetings and one major meeting on 1 August 1973 at the New England Division.

During the past six months we have been attempting to complete the installation of 27 ERTS data collection platforms. To date the 26 that have been installed are reporting hydrologic or related data on a near real time basis to the New England Division, Corps of Engineers in Waltham, Massachusetts. Analyses to date indicate the usefulness and high degree of reliability of the information with a minimum of maintenance necessary. Data received was used for operational purposes during the December floods in New England.

The best uses of ERTS imagery for watershed management purposes appear to be: delineation of flooded areas, snow cover, and icing of rivers, lakes and reservoirs. A man/computer interactive system with CRT and light pen for real time image processing continues to be studied for its potential contribution to the application of ERTS computer imagery for important water resource management decisions.

Work is now proceeding on our final report concerning the possible future usefulness of satellites such as ERTS in the day-to-day operation of Corps of Engineers water resource projects.

The body of this report will be divided between our DCS studies and those involving ERTS imagery and imagery/DCS interactions.

TABLE 1

ERTS-1 - DCP INFORMATION SHEET
ARMY CORPS OF ENGINEERS, NEW ENGLAND DIVISION

10 JAN, 1974

ID NO.	DCP NO.	TYPE*	STATION NAME	LAT	LONG	IN-STALLED
1	6233	S	ST. JOHN RIVER AT FORT KENT, MAINE	47 15	68 35	091972
8	6220	S	ST. JOHN RIVER AT NINEMILE BR., MAINE	46 42	69 43	073073
2	6355	S	PENOBSCOT RIVER AT WEST ENFIELD, MAINE	45 14	68 39	092072
3	6271	S	CARABASSETT RIVER AT NORTH ANSON, MAINE	44 52	69 57	100472
5	6171	S	SACO RIVER AT CORNISH, MAINE	43 48	70 47	112872
6	6273	S	PEMIGEWASSET RIVER AT PLYMOUTH, N.H.	43 45	71 41	112272
7	6304	S	MERRIMACK RIVER AT GOFFS FALLS, N.H.	42 57	71 28	032773
9	6356	S	CHARLES R. AT CHARLES R. VILLAGE, MASS.	42 15	71 15	071772
10	6207	S	TOWN BROOK AT QUINCY, MASS.	42 15	71 00	090872
41	6142	S	NORTH NASHUA RIVER AT FITCHBURG, MASS.	42 34	71 47	110672
11	6010	S	PAWTUXET RIVER AT CRANSTON, R.I.	41 45	71 27	083072
13	6106	S	BRANCH RIVER AT FORESTDALE, R.I.	42 00	71 34	100173
12	6127	S	CONNECTICUT RIVER AT HARTFORD, CONN.	41 46	72 40	083072
20	6021	P	STINSON MOUNTAIN, N.H.	43 50	71 47	032273
21	6345	P	SOUTH MOUNTAIN, N.H.	42 59	71 35	120672
22	6206	P	FRANKLIN FALLS DAM, N.H.	43 28	71 40	051773
23	6201	P	BLACKWATER DAM, N.H.	43 19	71 44	100273
24	6012	P	MACDOWELL DAM, N.H.	42 54	71 59	042473
26	6071	P	WACHUSETT MOUNTAIN, MASS.	42 29	71 53	100473
25		P	MANSFIELD HOLLOW DAM, CONNECTICUT	41 46	72 11	
30	6101	C	STAMFORD BARRIER, STAMFORD, CONNECTICUT	41 02	73 32	011073
40	6254	Q	ASHUELOT RIVER AT WINCHESTER, N.H.	42 47	72 23	121272
42	6272	Q	WESTFIELD R. AT WEST SPRINGFIELD, MASS.	42 06	72 38	092872
43	6242	Q	CHICOPEE RIVER AT CHICOPEE, MASS.	42 09	72 35	121472
50	6147	T	NED HEADQUARTERS, WALTHAM, MASS.	42 24	71 13	071772
51	6325	T	COLD REGIONS LAB AT HANOVER, N.H.	VARIABLE		042373
52	6216	T	COLD REGIONS LAB AT HANOVER, N.H.	VARIABLE		120572
54	6063	T	U.S. GEOLOGICAL SURVEY, BOSTON, MASS.	VARIABLE		032073

* S-RIVER STAGE

P-PRECIPITATION

C-COASTAL (WIND DIRECTION, VELOCITY AND TIDE)

Q-WATER QUALITY (TEMPERATURE, CONDUCTIVITY, PH AND DISSOLVED OXYGEN)

T-TEST SET (SENSORS VARIABLE)

TABLE 2

OPERATIONAL DCP LIFE
(FOR ENTIRE ERTS EXPERIMENTAL
PERIOD THROUGH 31 DECEMBER 1973)

DCP's Having No Failures	DCP's Having One Failure		DCP's Having Two Failures		DCP's Having Three Failures
<u>Life in Months</u>	<u>Life Before Failure (mos.)</u>	<u>Life Since Failure (mos.)</u>	<u>Life Before Failures (mos.)</u>	<u>Life Since Last Failure (mos.)</u>	<u>Life Before Failures (mos.)</u>
15	9	1	5, 2	3	2, 1, 2
8	8	3	2, 4	5	
8	7				
9*	1	3	2, 2	2	
16					
14					
9					
12					
9*					
5*					
12					
12					
7					
5					
13					
13					
16					
15					
Total of 18 DCP's never experiencing a failure	Total of 4 DCP's ex- periencing just one failure each		Total of 3 DCP's ex- periencing two failures each		One DCP ex- periencing three failures

* Indicates DCP was received defective
and repaired before installation

four, 6-volt batteries connected in series) continue to perform well, lasting up to 12 months without recharging. However, it appears that if a set of batteries is allowed to discharge below a certain limit ($20\frac{1}{2}$ volts) its ability to hold a recharge is greatly reduced. Such recharged batteries discharge more rapidly under load and are more susceptible to failure during cold weather than new batteries.

The overall system performance is summarized as follows: Considering only DCP's that have been in operation for at least six months (to allow a reasonable time for a failure to occur), there have been 233 operational DCP months. One DCP month is equivalent to one DCP operating for a month. In this time period there have been a total of 27 system failures, i. e., no transmissions from a DCP location until DCP and/or battery replacement was made. This yields an expected average system lifetime before failure of 8.63 months.

It should be noted that 9 out of the last 10 DCP system failures were battery-related. Most of the early system failures were installation-related (improper grounding), and many of the more recent system failures were attributable to previously defective DCP's. It is our opinion that repaired DCP's have a greater potential for failure than nonrejuvenated units. Also, it appears that DCP's which survive an initial 3 to 5 month operational period have a low probability of failure. Standard maintenance on these platforms would then consist only of periodic battery replacement.

All DCP maintenance/repair work was performed at CRREL during the reporting period.

Since the last six-month report, sensor utility has been good. Precipitation, river stage, and coastal wind velocity sensors have proven essentially problem free. Coastal station sensors for wind direction and tide are not yet installed. The only significant sensor-related problems have concerned the water quality stations. In two cases the sensors have been subjected to such heavy buildup of solid wastes that failure of the monitoring apparatus resulted. Relocation of the equipment to cleaner waters will be accomplished this spring.

2.2.3 DCS Data Acquisition and Storage

DCS data acquisition is continuing in the form of punched paper tape and teletype printout from the near real time teletype link while punchcards and computer printouts continue to be received by mail.

Data storage for the paper tape mode is not complete due to continuing problems in computer software and hardware acquisition. A software interface program has been written which will store DCS real time link data on disk storage in the Data General mini-computer, however, we are having difficulty resolving an internal software problem with the Data General computer. We hope to settle this temporary setback soon, with assistance from Data General technicians. A multiple-disk storage unit for the Data General is presently in the acquisition phase. A "Request for Proposals" for provision of this equipment was issued by the New England Division, and several suppliers have received the solicitation.

Ground truth data from U.S. Geological Survey data collection equipment is currently being compared with Goddard Space Flight Center punchcard data. Results indicate a high degree of favorable comparison between the independently acquired data banks.

2.2.4 DCS Studies

The following definitions are required:

- a. Signal - A radio beam sent every three minutes by a DCP
- b. Message - A signal relayed by ERTS-1 to NASA
- c. Report - All messages transmitted during a single pass of ERTS-1 from a particular DCP

Data is being stored for computer processing from punchcards, with the data separated by DCP number and time of report and then analyzed.

As of 20 September 1973 a significant change was made

in the criteria for transmitting ERTS data from NASA to NED. Previously, only the highest confidence level (#7) data had been transmitted from NASA. It was established, however, that meaningful operational statistics could only be derived if all data (confidence levels 0 through 7) were received at NED, and so commencing on this date data was received from NASA regardless of confidence level.

With the acquisition of a new data base, it was necessary to establish revised criteria for a "GOOD REPORT". A report is now considered "GOOD" if:

a. It consists of only one message, has a NASA confidence level of 7, and has a valid bit pattern, or

b. It consists of multiple messages, has agreement between any two consecutive messages within certain NED established limits*, and has a valid bit pattern.

*Limits are: River Stage: $\leq 0.19'$ difference
between messages

Precipitation: $\leq 0.19''$ difference
between messages

Water Quality: no difference
between messages

DCS reliability (percent of Good Reports/Total Reports received) continues to be very high. Based on the operational DCP's, and using the new data base, reliability of the system is 98.9 percent (see table 3).

Indications, based on the geographically varied locations of DCP's, are that mountaintop and coastal stations have consistently excellent fields of view. Masking has been evident at stations located in mountainous terrain and forested areas. Detailed field of view statistics are reported in table 4.

A water quality monitoring system containing sensors measuring depth below the water surface, water temperature, conductivity, pH and dissolved oxygen, as well as air temperature was installed for test purposes at the Wilder Dam on the Connecticut

TABLE 3

DCS RELIABILITY STATISTICS
(FOR THE PERIOD 20 SEPTEMBER 1973
THROUGH 31 DECEMBER 1973)

<u>DCP Site ID Number</u>	<u>Good Reports</u>	<u>Total Reports Received</u>	<u>Percent Good/ Total Received</u>
3	213	215	99.0
5	261	261	100.0
6	395	396	99.8
7	413	424	97.2
8	436	442	98.7
9	437	440	99.4
10	291	297	98.0
11	427	427	100.0
12	470	476	98.8
13	446	451	98.8
41	493	501	98.5
20	252	256	98.5
21	523	525	99.7
22	434	437	99.6
24	362	369	98.2
26	113	114	99.0
42	229	235	97.5
43	239	240	99.5
Total	6,434	6,506	98.89

TABLE 4
FIELD OF VIEW STATISTICS
FOR DCP LOCATIONS
(FOR ENTIRE ERTS EXPERIMENTAL PERIOD
THROUGH 31 DECEMBER 1973)

<u>DCP Site ID Number</u>	<u>General Location</u>	<u>Total Reports Possible Per 18 Days</u>	<u>Remarks</u>
1	on river	88	Wide river channel, DCP in open field
2	on river	90	Clear area on wide river channel, except for large tree directly over DCP
3	on river	82	Dense woods on bankside of DCP, narrow river channel
4	on river	78	Surrounded by large overhanging trees, site no longer in use
5	on river	83	High trees on bankside of DCP
6	on river	79	DCP in shadow of a large tree - many other trees around
7	on river	88	Clear view on wide river channel
8	on river	92	Clear view on wide river channel
9	on river	79	Lots of trees over DCP
10	on river	83	DCP in urban area in field - possible interference from nearby houses and buildings
11	on river	81	Open area on wide river channel
12	on river	90	Clear view on wide river channel
13	on river	78	Surrounded by many overhanging trees
40	on river	82	Narrow river channel, high trees on both riverbanks
41	on river	87	Clear view
42	on river	81	Trees and buildings on one side of DCP
43	on river	88	Clear view
20	mtn top	94	Clear view
21	mtn top	90	Clear view
26	mtn top	95	Clear view, surrounded by radio antennas
22	damsite	90	Clear view
24	damsite	86	Clear view
30	coastal	90	Clear view, DCP at hurricane barrier

River in New Hampshire by CRREL on 29 October 1973. The system, interfaced with a DCP, was in operation until 19 December 1973. The site proved to be an ideal location, considering the variable parameters, convenience of a shelter for equipment housing and availability of external power. At times heavy debris concentrations passed the sensors. Logs as large as 14 feet long were snagged without damaging the sensors or significantly influencing the sensor readings (a slight change in depth was noticed).

Calibrations were performed on 29 October and 5, 13 and 19 November. The sensor package maintained an acceptable degree of accuracy during the testing period. Data received through the ERTS near real time data collection system was comparable with ground truth information recorded by the instruments.

2.2.5 ERTS DCS Downlink

Since overall performance of the DCP's has continued to be very satisfactory, we have submitted a proposal to NASA for the acquisition of a real time direct satellite downlink to be installed at the Waltham, Massachusetts complex. This system would prove invaluable from a prototype, operational standpoint. We are firmly convinced that the concept of regional downlinks must be considered, and such a setup physically tested, in relation to the development of the specifications for any operational satellite data collection system. We are hoping for a favorable reply from NASA by spring 1974.

2.2.6 Program for Next Reporting Interval

Studies will continue towards comparison of conventional ground-based radio relay systems with ERTS DCS, with emphasis on cost and performance. CRREL will continue interfacing and testing various environmental sensors with the DCP's. We will keep pursuing our interest in having an ERTS DCS downlink at our Waltham headquarters.

2.2.7 Conclusions

DCP's tested during this experimental program continue to show high performance characteristics. We suggest that the successful testing of the ERTS-1 Data Collection System at the New England Division should encourage serious consideration of the

institution of an operational satellite data relay system Corps-wide provided the cost is competitive with existing systems. Emphasis should be placed upon a system consisting of two or three orbiting satellites or one geosynchronous satellite in order to yield more frequent data than ERTS-1.

2.3 ERTS-1 DATA COLLECTION WORKSHOP

During the reporting period we continued to participate in the preparation of the Proceedings of the ERTS-1 Data Collection Workshop held at Wallops Station, Virginia on 30-31 May 1973. We are continuing to cooperate in this with NASA personnel at Goddard Space Flight Center, Maryland and Wallops Station, Virginia. The Proceedings will be published in early 1974.

2.4 QUESTIONNAIRE TO DETERMINE CORPS-WIDE NEED FOR AUTOMATED DATA COLLECTION

During the past six months we have received completed questionnaires from Corps of Engineers offices throughout the United States relating to present status of and future needs for automated data collection facilities (see July 1973, Type II Report for a copy of the questionnaire). The results of this survey have been tabulated and are presented in Appendix A. A complete discussion of the implications of these results will be available in our final study report.

3.0 IMAGERY AND IMAGERY/DCS INTERACTION STUDIES

3.1 BACKGROUND

Work is now proceeding on our final report concerning the application of ERTS imagery to provide useful and timely hydrologic information for the New England Division Reservoir Control Center management purposes. The overall plan of study is described in a Service Contract, dated 30 June 1972, between the New England Division, Corps of Engineers and the University of Connecticut for NASA-ERTS Imagery Study, with recent amendments, dated 21 November 1973, extending the contract period through 30 June 1974.

3.2 IMAGERY PHOTO INTERPRETATION

3.2.1. Introduction

The parameters that have undergone study in this investigation of ERTS photo products are:

- a. Flood storage characteristics of river flood plains and wetlands
- b. Snow cover
- c. Icing on rivers, lakes and reservoirs

3.2.2 Summary of Progress

3.2.2.1 Flood Storage Characteristics of River Flood Plains and Wetlands

ERTS imagery taken during both flood and nonflood periods has been obtained for portions of both the Connecticut and Merrimack River basins. The pattern of flooding may be delineated by comparison of the imagery taken during a flood period and the imagery taken over the same area during a dry period. Procedures for obtaining composite images where flooded areas are prominently displayed have been developed and will be described in detail in our final report. Information so obtained in this manner can provide important input to evaluation of the areal extent of the flood storage capabilities of flood plains and wetlands.

The suggested role of ERTS imagery in such evaluations is outlined in our July 1973 Type II Report.

3.2.2.2 Snow Cover

An extensive study has been made concerning the ability of ERTS imagery to detect the degree of snowmelt over a watershed area during a 24-hour period. The 24-hour repeat coverage is possible once every 18 days by virtue of the imagery overlap experienced by adjacent ERTS orbital paths. A comparison of the amount of snowmelt runoff suggested by ERTS imagery information combined with weekly snow course measurements was made with actual river gaging station runoff records for 6-7 April 1973 over the Contoocook River basin in New Hampshire. A complete writeup of this analysis and the implications for the potential contribution of

ERTS or similar satellite surveillance to augment snow course information is in preparation and will be included in our final report. Procedures for preparing the composite imagery products which display changes in snow coverage from one image to another will be reported at the same time.

3.2.2.3 Icing of Rivers, Lakes and Reservoirs

The same image overlap features referred to in the previous section make possible the assessment of changes in ice coverage on rivers, lakes and reservoirs between successive days, once every 18 days.

Procedures for preparing composite images which display the changes will be discussed and illustrated in our final report.

3.2.2.4 Imagery Mosaics

During the 6-month period ending 30 December 1973 CRREL completed and delivered to NED, for display purposes, two identical ERTS-1 imagery mosaics of all New England at a scale of 1:500,000. These were constructed of a mixture of MSS-6 and 7 scenes taken during September and October 1972 and are negative renditions to enhance surficial waters.

3.2.3 Program for Next Reporting Interval

Our efforts will be directed towards our final report concerning the possible future usefulness of ERTS-type imagery in the day-to-day operation of Corps of Engineers water resource projects. Special emphasis will be placed, where applicable, on data and imagery obtained for the record early summer 1973 floods in Vermont and New Hampshire.

3.2.4 Conclusions

Flood storage characteristics of river flood plains and wetlands can be delineated by use of imagery photo interpretation techniques. Photo interpretation also appears well suited in the preparation of snow maps and in following the progress of icing of rivers, lakes and reservoirs. Repetitive imagery coverage is the key to all of these applications and operational usefulness of the system can be improved with more frequent imaging of all areas.

Mosaics of ERTS-1 imagery covering the New England States, constructed at CRREL, continue to provide impressive synoptic views of the hydrologic and geologic features of our region.

3.3 IMAGERY COMPUTER-ORIENTED ANALYSIS

3.3.1 Introduction

Our long range goal in this area is to investigate new means for the automatic interpretation of ERTS imagery relevant to NED water resources management missions.

3.3.2 Summary of Progress

3.3.2.1 Investigation of Turbidity and Sedimentation Using Computer Imagery

Studies of the utility of ERTS computer imagery for determining the location, areal coverage, depth and other characteristics of surface waters are described in detail in our July 1973 Type II Report. We are preparing conclusive statements regarding these parameters for inclusion in our final study report.

3.3.2.2 Man/Computer Interactive System for Image Processing

Work is continuing in the development of a man/computer interactive system, with a cathode ray tube (CRT) and light pen, that could allow real time analysis and utilization of ERTS computer imagery for important water resource management decisions. Recommendations concerning the means by which such a system could be implemented at the New England Division will appear in our final study report.

3.3.3 Program for Next Reporting Interval

Our main thrust will be the preparation of our final report concerning the potential usefulness of ERTS-type computer imagery products for determining the location and other characteristics of surface water bodies. We will continue to develop a man/interactive system for real time computer imagery analysis.

3.3.4 Conclusions

Our studies, to date, have clearly demonstrated the usefulness of computerized image data processing techniques for providing important information for watershed management purposes. Our work on a man/computer interactive system for real time imagery analysis continues to show great promise for enhancing the operational usefulness of satellite imagery to NED.

4.0 CONTACTS WITH OTHER INVESTIGATORS, ORGANIZATIONS AND THE GENERAL PUBLIC

Two individuals involved in our ERTS experiment attended the NASA Symposium during the week of 10 December 1973. At this meeting, Mr. Cooper (P.I.) presented a paper entitled: "A Real Time Data Acquisition System by Satellite Relay."

On 2 November 1973, Mr. Cooper gave a briefing on our ERTS experiment to a general audience at the Corps of Engineers Washington headquarters. During the week of 26-30 November, he attended a Corps-wide Remote Sensing Conference held at Johnson Space Center, Houston, Texas and presented a talk concerning the data collection portion of the investigation. On 12 December 1973, Mr. Horowitz gave a briefing to the Corps of Engineers Research hierarchy assembled at our Washington headquarters for a Research Coordinating Conference.

During the reporting period we have continued to keep in close contact with other ERTS Principal Investigators and interested personnel from the U.S. Department of the Interior, National Oceanic and Atmospheric Administration and NASA. In addition, we have presented the story of our ERTS investigation at meetings of the Boston Chapter of the American Society of Military Engineers (Mr. Cooper - 13 November) and the Boston Society of Civil Engineers (Dr. Bock - 12 December).

APPENDIX A

RESULTS OF THE
QUESTIONNAIRE TO DETERMINE
CORPS-WIDE NEED FOR
AUTOMATED DATA COLLECTION



DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02154

REPLY TO
ATTENTION OF:

NEDED-W

17 December 1973

SUBJECT: Results of Questionnaire on Real Time Data Collection
Systems

Division Engineers
District Engineers

1. All Districts and Divisions responded to the questionnaire and the data have been compiled, summarized and tabulated. A copy of the results is inclosed for your information.
2. During telephone conversations with the Districts and Divisions it was pointed out that by "real time data", we meant unmanned, automated stations. This has been reflected in the summary which shows that 3,970 of 4,437 proposed stations would be fully automated.

FOR THE DIVISION ENGINEER:

1 Incl
as


SAUL COOPER
Principal Investigator

QUESTIONNAIRE
TO DETERMINE THE CORPS-WIDE NEED
FOR AUTOMATED DATA COLLECTION

RESPONSE: ALL DIVISIONS-ALL DISTRICTS

- A. At present does your office collect hydrologic or other environmental data from field locations on a near real time basis?

YES ☐

NO ☐

- B. If the answer to (A) is "Yes", enter the number of locations:

Telemark	<input type="checkbox"/>	623
Ground-based radio relay	<input type="checkbox"/>	844
Earth satellite relay	<input type="checkbox"/>	—
Other (specify type)	<input type="checkbox"/>	2347
(Telephone and/or Teletype)		
METS SYSTEM		46
TOTAL		3860

(Use additional pages for continuation)

- C. Enter the number of locations reporting each of the parameters listed below:

River stage	<input type="checkbox"/>	1971
Precipitation	<input type="checkbox"/>	2230
Snow cover	<input type="checkbox"/>	925
Wind speed and/or direction	<input type="checkbox"/>	109
Barometric pressure	<input type="checkbox"/>	37

Tidal levels & Oceanographic	<input type="checkbox"/>	108
Air or soil temperature	<input type="checkbox"/>	168
Air or soil moisture	<input type="checkbox"/>	48
Water quality	<input type="checkbox"/>	345
Other (specify type)	<input type="checkbox"/>	181
TOTAL :		6122

(Use additional pages for continuation)

D. How many field locations do you feel would adequately fulfill your near real time data collection needs as projected over the next five years? ☐ **4437**

E. Maximum number of parameters at any one site ☐ **2-27**

Minimum number of parameters at any one site ☐ **1-5**

Average number of parameters at any one site ☐ **1-15**

F. Based on your 5-year project in question D, enter the required number of locations to measure each of the following parameters:

Column 1 - Parameter

Column 2 - Number of locations

Column 3 - Frequency desired such as "continuous", "every so many hours", "days", "weeks", etc.

Column 4 - How important to interrogate on call - (1) indicates very important and (5) indicates no need.

(1) Parameter	(2)	(3)	(4)
River stage			
Precipitation			
Snow cover			
Wind speed and/or direction			
Barometric pressure			
Tidal levels			
Air or soil temperature			
Air or soil moisture			
Water quality			
Other (specify type)			

G. How many stations would you expect to place in each of the following types of physical locations?

Along rivers or lakes

2171

At coastal sites

157

On mountaintops

116

In woods

120

In fields

206

In the middle of a town or city

214

Other (specify) **Unspecified**

1453

TOTAL:

4437

(Use additional pages for continuation)

SUMMARY OF ERTS QUESTIONNAIRE
INTERROGATION TIME REQUIREMENTS

<u>PARAMETERS</u>	<u>Number and Time of Parameters</u>									
	Continuous	1-Hour	2-Hour	3-Hour	6-Hour	8-Hour	12-Hour	24-Hour	Weekly	2-Week
River Data (Stage, Tailwater, Current, Discharge)	732	480	60		227	325	23	106		
Precipitation	310	430	36	351	240	17	100	361		
Reservoir or Lake Stage	21	17	19		17					
Snow Cover	84	10	7		319			75	68	
Wind Speed and/or Direction	42	10				8		193		
Barometric Pressure	10							16		
Oceanographic Data (Tide Level, Current, etc.)	87							94		
Air or Soil Temperature	10	55	3					190		20
Air or Soil Moisture		60						49		
Water Quality Data	154	49		3	8		1	187	26	20
Evaporation								10		
Spillway Gate Opening		15								
Solar Radiation		5								
Totals	1450	1131	125	354	811	350	124	1281	94	40

5

SUMMARY OF INVESTIGATION #MMC 89:
THE USE OF ERTS IMAGERY IN RESERVOIR
MANAGEMENT AND OPERATION

CO-PRINCIPAL INVESTIGATORS:
MR. SAUL COOPER
DR. PAUL BOCK

FOR DISCIPLINE 4: WATER RESOURCES

Studies at the New England Division, Corps of Engineers are focused on evaluating the possible usefulness of ERTS DCS and imagery to its watershed management functions. As of 31 December 1973 we have installed 26 of 27 DCP's scheduled for field use that report hydrologic and related information to the New England Division on a near real time basis via a direct teletype link with Goddard Space Flight Center. DCS equipment is operating with a high degree of reliability and a minimum of maintenance and has again been used in an operational mode during a significant flood period.

The results of a Corps-wide questionnaire regarding automated data collection have been compiled, and indicate a projected need, over the next five years, for almost 4,000 unmanned, automated stations to relay near real time data from field locations to Corps offices. In view of the importance of continuing to study the possibilities of data relay by satellite, we have submitted a proposal to NASA for the acquisition of a real time direct satellite downlink to be installed at our Waltham, Massachusetts complex. We are firmly convinced that the concept of regional downlinks must be considered and physically tested in relation to the development of the specifications for any operational satellite data collection system. During this reporting period, we have continued to participate in the preparation of the Proceedings of the ERTS-1 Data Collection Workshop held at Wallops Station, Virginia on 30-31 May 1973. The Proceedings are expected to be published in early 1974.

We have found that flood storage characteristics of river flood

plains and wetlands can be delineated by the application of photo interpretation techniques to ERTS imagery. Photo interpretation also appears well suited in aiding the preparation of snow maps and in following the progress of icing of rivers, lakes and reservoirs. More frequent repetitive imagery coverage of all areas would vastly increase the operational usefulness of the system. Mosaics of ERTS-1 imagery covering the New England States and constructed at the U.S. Army Cold Regions Research and Engineering Laboratory continue to provide impressive synoptic views of the hydrologic and geologic features of our region.

Our studies with ERTS computer compatible tapes have clearly demonstrated the usefulness of computerized image data processing techniques for providing important information for watershed management purposes, especially relative to the location and other characteristics of surface water bodies. Our work on a man/computer interactive system for real time imagery analysis continues to show great promise for enhancing the operational usefulness of satellite imagery to the New England Division.

SUMMARY OF INVESTIGATION #MMC 89:
THE USE OF ERTS IMAGERY IN RESERVOIR
MANAGEMENT AND OPERATION

CO-PRINCIPAL INVESTIGATORS:
MR. SAUL COOPER
DR. PAUL BOCK

FOR SUBDISCIPLINE 9B: SENSOR
TECHNOLOGY - DATA COLLECTION PLATFORMS

The Data Collection System operated by the New England Division, Corps of Engineers, Waltham, Massachusetts is collecting hydro-meteorological information (primarily river stage, precipitation and water quality parameters) on a near real time basis with the aid of a teletype link with the Goddard Space Flight Center. We are evaluating the possible usefulness of DCS to our watershed management functions. To date, we have installed 26 of 27 DCP's scheduled for field use. DCS equipment is operating with a high degree of reliability and a minimum of maintenance and has again been used in an operational mode during a significant flood period. The results of a Corps-wide questionnaire regarding automated data collection have been compiled, and indicate a projected need, over the next five years, for almost 4,000 unmanned, automated stations to relay near real time data from field locations to Corps offices. In view of the importance of continuing to study the possibilities of data relay by satellite, we have submitted a proposal to NASA for the acquisition of a real time direct satellite downlink to be installed at our Waltham, Massachusetts complex. We are firmly convinced that the concept of regional downlinks must be considered and physically tested in relation to the development of the specifications for any operational satellite data collection system. We have continued, during this reporting period, to participate in the preparation of the Proceedings of the ERTS-1 Data Collection Workshop held at Wallops Station, Virginia on 30-31 May 1973. The Proceedings are expected to be published in early 1974.